Diabetes and Oral Health: The Importance of Oral Health–Related Behavior

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Introduction

Diabetes mellitus is a chronic debilitating disease that is gaining ground as a global epidemic, and is a major public health concern and economic burden in the U.S.[1,2] According to the statistics provided by the National Institute of Diabetes and Digestive and Kidney Diseases, 23.6 million U.S. citizens have diabetes and 57 million adults aged 20 years and older have pre–diabetes, resulting in a total of 80.6 million U.S. citizens who were either diagnosed as diabetic or pre–diabetic.[3] Given the potential for severe oral health complications of diabetes and the steady increase in the incidence of the disease, it is crucial to understand the role of dental hygienists in this context.[4,5] This study shows that patients diagnosed with diabetes do indeed have poorer oral health than patients that were not diagnosed with diabetes, and investigates whether there are differences in the oral health–related behavior of these 2 groups of patients. Finally, this study demonstrates the importance of oral health promotion efforts for the oral health of patients with diabetes by comparing the oral health status of patients with diabetes and of patients not diagnosed with diabetes.

Abstract

Purpose: The objective of this study was to explore oral health–related behavior, how patients with diabetes differ from patients not diagnosed with diabetes in their oral health and whether oral health–related behavior moderates the oral health status of patients with diabetes.

Methods: Survey and chart review data were collected from 448 patients (52% male, 48% female, average age: 57 years) of which 77 were diagnosed with diabetes (17%).

Results: Patients with diabetes had a higher percentage of teeth with mobility than those not diagnosed with diabetes (14% vs. 8%, p=0.023), as well as gingival recession (16% vs. 12%, p=0.035) and more teeth with recession in the esthetic zone (1.17 vs. 0.88, p=0.046). They also had more decayed, missing and filled surfaces due to caries (101 vs. 82, p<0.001) and more missing teeth due to caries (11 vs. 7, p<0.001). Patients with diabetes brushed and flossed less frequently. Patients with diabetes who did not brush regularly had poorer periodontal health (percentage of teeth with probing depth of <4 mm: 82% vs. 60%, p=0.039, 4 to 6 mm: 34% vs. 17%, p=0.059) and more caries (percentage of decayed teeth: 32% vs. 15%, p=0.033) than regularly brushing patients with diabetes.

Conclusion: Educating patients with diabetes about the importance of good oral self care needs to become a priority for their oral health care providers.

Keywords: Diabetes, periodontal disease, caries, tooth brushing, oral hygiene, oral hygiene education

This study supports the NDHRA priority area, **Health Promotion/ Disease Prevention:** Investigate the effectiveness of oral self–care behaviors that prevent or reduce oral diseases among all age, social and cultural groups.

Review of the Literature

The complications of diabetes are numerous and include nephropathy, retinopathy, neuropathy, peripheral vascular disease, coronary artery disease and severe oral health complications.[4–6] Research has documented relationships between diabetes and oral health diseases such as periodontitis, dental caries, oral mucosal lesions, burning mouth syndrome, xerostomia and tooth loss.[5,7–12] Concerning the effects of diabetes on the periodontium, Tsai et al showed in 2002 that there is a strong relationship between periodontal health and glycemic control.[13] On one hand, poor glycemic control in patients with diabetes is related to increased severity of periodontal disease.[11,14] On the other hand, severe periodontal disease can result in poor glycemic

control and other complications.[15-17] These relationships have been widely investigated and the consensus is that there is a bidirectional relationship between these chronic conditions.[16,18]

In addition to the findings concerning the relationship between diabetes and periodontal disease, research also shows that patients with diabetes have a tendency for increased caries activity.[18,19] While the relationship between caries and diabetic control has not been as clearly established as the relationship between diabetes and periodontal disease, research showed that patients with diabetes have an increase in cariogenic bacteria, higher plaque levels, increased root surface caries and higher numbers of decayed, missing and filled teeth (DMFT) due to caries, compared to patients without diabetes.[18,20,21]

Additional research shows that patients with diabetes have increased tooth loss,[11,12] most likely due to multiple causes, such as increased periodontal disease and caries, as well as delayed wound healing due to macrovascular and microvascular changes and taste alterations.[21,22] Other neurosensory disorders, like dysphagia and burning mouth syndrome, have been reported and could be related to salivary flow, change in food intake and neuropathy.[9] Patients with diabetes also reportedly have an increase in the incidence of fungal lesions, which may be explained by the immunocompromised state and reduced salivary flow.[23] These findings underline the fact that patients with diabetes tend to be systemically compromised and that their oral environment is also compromised due to the reduction in the buffering capacity and volume of their saliva and the change in bacterial flora.[20]

When considering the complications of diabetes, it is crucial to acknowledge that lifestyle changes and long term behavior modification strategies can significantly reduce the morbidity and mortality of these patients.[5] Concerning oral health–related consequences, research shows that a lack of knowledge about the relationship between diabetes and oral health can lead to poor oral health–related behavior.[24] For example, there is evidence that patients with diabetes may have a lower utilization rate of dental care services.[15] In addition, Syrjala et al reported that patients with diabetes might have poorer oral health–related behavior compared to patients without diabetes, and suggested that oral health care and diabetic care are related.[25] Research also suggests that patients with diabetes who have better oral self care also have better glycemic control.[14,2]

This study explores whether good oral hygiene efforts in patients with diabetes also result in significantly improved oral health.

Based on the findings of earlier research, the current study has 3 objectives:

1. To investigate whether patients diagnosed with diabetes have poorer oral health than patients not diagnosed with this disease
2. To investigate the differences in oral health–related behavior between these 2 groups of patients
3. To analyze whether there are differences in the oral health of patients with diabetes who engage in good oral hygiene efforts versus patients with diabetes with poor oral self care behaviors

If such differences can be demonstrated, they would provide a strong basis to argue that dental hygienists must take on the responsibility of educating patients with diabetes about the importance of sound oral hygiene practices for the oral health of these patients.

Methods and Materials

This study was approved by the Institutional Review Board for the Health Sciences of the University of Michigan, in Ann Arbor, Michigan. Table I provides an overview of the respondent characteristics. Data were collected from 443 adult patients (male: 229, 52%, female: 213, 48%) at the pre–doctoral dental clinics at the University of Michigan School of Dentistry. The patients ranged in age from 18 to 72 years (mean=56.52, SD=16.584), were predominantly European American (72.6%), African American (9.3%), Hispanic (1.6%) and Asian/Pacific Islanders (1.6%), and had, on average, 13.91 years of schooling (SD=2.841). A total of 77 patients self–reported that they had been diagnosed with diabetes. The remaining 366 patients were included in this study as the control group subjects.

When the patients arrived for a regularly scheduled dental appointment, they were informed in the waiting area about the study. They were required to provide written consent and sign a Health Information Privacy Act Agreement to be able to participate in the study. They either self administered the questionnaire or the survey questions were asked in a face–to–face interview if the patients were unable to read the questions. If the questions were read to the patients, no explanations were provided. The clinical charts of the patients were reviewed to collect objective oral health data.

The survey included questions concerning the patients' socio–demographic background (gender, age,

ethnicity/race and years of schooling), oral health–related behavior (frequency of brushing, flossing and whether the patients had visited the dentist during the past year) and whether the patients had been previously diagnosed with diabetes. The questions concerning the frequency of brushing and flossing were taken from the National Health and Nutrition Survey.[27]

The oral health data was collected in a chart review. All exams reported in these chart reviews were conducted by dental students in the same institution who were all educated in the same manner and were all closely supervised by dental school faculty. The chart review data included indicators of the degree of periodontal disease, of caries and the number of missing teeth. The first periodontal indicator was a global rating of the patients' gingival health with the 3 categories (good, fair and poor). These assessments were made by the providers according to their instruction to rate the gingival health based on the color, contour, consistency of the gingiva and bleeding on probing with these 3 general categories. The second set of periodontal indicators were the percentages of teeth with pocket depths of <4 mm, 4 to 6 mm and >6mm at the day of the data collection and at the prior appointment. The pocket depth was measured from the gingival margin to the depth of the pocket using a Michigan "O" probe. No data was available to determine the length between the current and prior appointment.

Both the measurements of bleeding on probing and periodontal probing depth were determined on all teeth present. Instead of using the number of teeth with mobility or gingival recession, this study included the percentage of teeth with mobility compared to the teeth present. This procedure was selected to account for the possibility that the number of extracted and missing teeth of patients with diabetes may differ from the numbers of the control group patients. A comparison of the absolute number of teeth with mobility and gingival recession would be affected by the differing numbers of teeth present in the 2 groups. In order to avoid this bias, the percentages of affected teeth compared to the teeth present were computed. However, because only the total number of teeth present was available, no determination of the percentage of teeth with recession in the esthetic zone could be computed because the number of teeth present in the esthetic zone was not available. Therefore, the num-

Table I: Background characteristics of the patients with vs. without diagnosed diabetes

	Diabetes – yes* n=77	Diabetes – no n=366	p–value
Gender: – male – female	 48 (62%) 29 (38%)	 181 (50%) 184 (50%)	0.028
Age: Mean/SD	64/12.7	55/16.9	<0.001
Ethnicity: – African American – European American – other	 5 (7%) 60 (79%) 11 (14%)	 35 (10%) 258 (72%) 67 (18%)	0.514
Years of schooling: Mean/SD	13/2.5	16.9/2.9	0.002
If diagnosis of diabetes: – No Insulin – Insulin	 44 (71%) 18 (29%)	 –––	

*The question used to identify patients with versus without diabetes asked: "Were you ever diagnosed with diabetes?"

ber of teeth with recession in the esthetic zone was not included in the analysis because no percentages could be computed.

Indicators of caries included the percentage of decayed teeth, determined clinically and observed on periapical and bite wing radiographs. Other indicators included the number of missing teeth due to caries, the number of extracted teeth, the percentages of restored teeth/crowns at the day of the data collection (as well as at a prior appointment) and the number of replaced missing teeth. The number of decayed, missing and filled surfaces (DMFS) due to caries and the number of DMFT due to caries scores were determined for each patient. Information about how many teeth were missing due to caries versus other reasons (such as removal of third molars) was collected as well.

Statistical Analysis

Descriptive statistics concerning the percentages of responses were computed to provide information about frequency distributions. Independent sample t–tests were used to determine how patients with diabetes versus patients without diabetes differed in their oral health and oral health–related behaviors, as well as patients with diabetes who brushed regularly versus those who did not brush regularly. The differences were measured with continuous answer scales. Chi–square tests were used to compare the responses of these groups to categorical questions, such as whether the patients were edentulous or not.

Results

Table I shows that patients with diabetes differed in 3 ways in their background characteristics from the control group respondents. They were more likely to be male, were on average about 9 years older and had about 4 fewer years of education on average than the control group subjects, who had not self–identified as having been diagnosed with diabetes.

Concerning the periodontal indicators, a global assessment of the patients' gingival health as either good, poor or fair was included in these analyses, as well as more specific measures obtained in periodontal exams, such as the percentage of teeth with <4 mm, 4 to 6 mm, more than 6 mm pocket depth and with mobility. Table II shows that there was a tendency for patients with diabetes to be more likely to have fair and poor gingival health. The patients with diabetes did not differ in the percentages of teeth with <4 mm, 4 to 6 mm and ≥6 mm probing depth. However, the 2 groups differed as predicted in the percentage of teeth with mobility, the percentage of teeth with gingival recession and the number of teeth with recession in the esthetic zone.

Table II also shows that the number of DMFS was significantly higher in the group of patients with diabetes compared to the group of patients without diabetes, while there was only a tendency for the DMFT score to differ as predicted. However, there was a clear difference in the number of missing teeth due to caries. Patients with diabetes missed on average 11.44 teeth due to caries, while patients not diagnosed with diabetes missed on average 6.94 teeth due to caries (p<0.001).

Table II: Oral health indicators of patients with vs. without diabetes

Indicators of gingivitis/periodontal disease	Diabetes – yes n=77	Diabetes – no n=366	p–value
Answer alternatives concerning gingival health:			
– good	43.3%	59.3%	0.056
– fair	44.8%	31.3%	
– poor	11.9%	9.4%	
% probing depth (last charting)			
– <4 mm	77%	72%	0.195
– 4–6 mm	21%	25%	0.109
– >6 mm	1%	2%	0.535
Percentage of teeth mobility	14%	8%	0.023
Percentage of teeth with gingival recession	16%	12%	0.035
Number of teeth with recession in esthetic zone	1.17	.88	0.046
Indicators of caries			
DMFS	100.62	81.64	<.001
DMFT	22.77	21.04	.083
Percentage of decayed teeth, clinically determined	19%	13%	.093
Number of missing teeth due to caries	11.44	6.94	<0.001
Percentage of restored teeth/crowns	50%	43%	0.239
Percentage of previously restored teeth	46%	43%	0.440
Missing teeth			
Number of missing teeth due to other reasons	3.49	3.56	0.730
Number of extracted teeth	14.93	10.47	<0.001
Number of replaced missing teeth	8.19	5.32	0.010

The data also showed that the 2 groups differed in number of extracted teeth as predicted. The patients with diabetes had on average 14.93 teeth extracted compared to the patients not diagnosed with diabetes who had only 10.47 teeth extracted (p<0.001). On average, 3.49 of these missing teeth in the group of patients with diabetes and 3.56 of these teeth in the group not diagnosed with diabetes were extracted for reasons not related to caries (Table II).

In addition to exploring oral health differences, the second objective was to determine whether these 2 groups differed in their oral health behavior, and whether patients with diabetes showed fewer oral health promotion efforts compared to patients without diagnosed diabetes. Table III illustrates that the data supported this hypothesis – 4.1% of patients with diabetes never brushed and 11% rarely

brushed. When compared to patients not diagnosed with diabetes, only 0.6% never brushed and 1.9% rarely brushed. The percentage of patients with diabetes who brushed at least once a day was 72.6% and 87.6% among patients who had not been diagnosed with diabetes (p<0.001). The 2 groups also differed as predicted in their flossing frequencies, with 52.8% of diabetic patients rarely or never flossing compared to 35.5% of the non–diabetic patients.

Table III: Percentages of responses concerning oral health–related behavior and BMI

Health–related behavior	Diabetes – Yes n=77	Diabetes – No n=366	p–value
Brushing:* – never – rarely – nearly every day – every day – >1 per day	4.1% 11% 12% 41.1% 31.5%	0.6% 1.9% 9.9% 38.6% 49.0%	<0.001
Flossing:** – never – rarely – nearly every day – every day – >1 per day	12.5% 40.3% 25% 19.4% 2.8%	11% 24.5% 29.5% 26.7% 8.3%	0.045
Dental visit during past year	86.7%	82.2%	0.226

*The question concerning brushing frequency asked: "How often do you brush your teeth?"

**The question concerning the flossing frequency asked: "How often do you floss your teeth?"

***The question concerning a visit to the dentist during the last years asked: "Other than today, did you visit a dentist during the last year?"

The third objective focused on exploring whether the degree to which patients with diabetes engage in oral health–related behavior contributes to the degree of oral disease they experience. For this purpose, the oral health indicators of the 72.6% of patients with diabetes who brushed at least once a day were compared with the oral health indicators of the 27.4% of patients who brushed less than once per day. Table IV shows that patients who brush regularly had fewer teeth with 4 to 6 mm pocket depth, and more healthy teeth with <4 mm pocket depth compared to patients who do not brush regularly. In addition, there is a tendency for the patients who do not brush regularly to have a higher percentage of teeth with bleeding on probing at their last visit compared to patients who brush regularly. One finding contradicts the expectations – patients who brush regularly have a higher percentage of teeth with gingival recession compared to patients who do not brush regularly.

Concerning the caries indicators, the data showed that patients who do not brush regularly had a significantly higher percentage of clinically and radiographically determined decayed teeth when compared to regularly brushing patients. In addition, there is a tendency for non–regularly brushing patients with diabetes to have a lower percentage of previously restored teeth compared to the regularly brushing patients with diabetes.

Table IV shows that there is a tendency for the non–regularly brushing patients with diabetes to

have, on average, more replaced missing teeth compared to the regularly brushing patients with diabetes.

Discussion

Before discussing the actual findings, it is important to realize that the patients included in this study self–reported their diagnosis of diabetes by responding to the question "Have you ever been diagnosed with diabetes?" This procedure has 2 implications for the interpretation of these findings. First, no differentiation by type of diabetes can be made, and no measure of blood glucose level had been determined. Second, it is likely that there might be a substantial percentage of non–diagnosed patients with diabetes or of pre–diabetic patients among the control group respondents. This argument is supported by epidemiological data. Between 1999 and 2002, an estimated 19.3 million U.S. adults 20 years of age or older were diabetic, yet only 6.5% were diagnosed and 2.8% had undiagnosed diabetes.[29] In addition, 26% had impaired fasting glucose levels, resulting in a total of 35.3% or 73.3 million U.S. citizens who were either diabetic or pre–diabetic.[28] Given these statistics, one could argue that the oral health differences found in these data might actually underestimate the extent to which diabetes affects oral health. Future research should include a random glucose level test to objectively determine the patients' diabetic status.

Table IV: Oral health indicators of patients with diabetes who brush vs. do not brush regularly

Indicators of gingivitis / periodontal disease	Regular brushing – No n = 20	Regular brushing – Yes n = 53	p–value
Answer alternatives concerning gingival health: – good – fair – poor	 25% 56.2% 18.8%	 48% 42% 10%	 0.244
% probing depth at last charting – <4 mm – 4–6 mm – >6 mm	 60.29% 34.10% 2.04%	 81.57% 16.73% 1.09%	 0.039 0.059 0.421
Percentage of teeth mobility	14.67%	14.16%	0.949
Percentage of teeth with bleeding on probing at last visit	21.11%	13.21%	0.099
Percentage of teeth with gingival recession	5.94%	18.29%	0.054
Number of teeth with recession in esthetic zone	0.53	1.39	0.125
Indicators of caries			
DMFS	99.5	95.48	0.724
DMFT	21.92	22.15	0.918
Percentage of decayed teeth, clinically determined	31.66%	15.01%	0.033
Percentage of decayed teeth determined radio graphically	14.95%	5.51%	0.041
Number of missing teeth due to caries	12.12	9.85	0.346
Percentage of restored teeth/crowns	31.93%	55.71%	0.09
Percentage of previously restored teeth	31.93%	51.02%	0.056
Missing teeth			
Number of missing teeth due to other reasons	3.25	3.54	0.337
Number of extracted teeth	15.38	13.38	0.435
Number of replaced missing teeth	11.33	7.20	0.082

A second limitation of this study was that the oral health related data were collected in a chart review. Having calibrated examiners collect the information concerning the patients' oral health status could have improved the quality of these data. However, even despite these problems, oral health differences were found between patients with diabetes and patients not having been diagnosed with diabetes – both in periodontal health as well as in caries indicators. Concerning periodontal health differences, the data showed that patients with diabetes had a higher percentage of teeth with mobility, a higher percentage of teeth with gingival recession and more teeth with recession in the esthetic zone compared to patients not diagnosed with diabetes. It is crucial for dental health care providers to be keenly aware of these differences, because not only

is poor glycemic control in patients with diabetes related to increased severity of periodontal disease, but severe periodontal disease can result in poor glycemic control and other complications.[11,15–17,29]

Regarding differences in caries indicators, the data also supports prior research findings. Patients with diabetes had significantly more DMFS and more teeth due to caries compared to patients not diagnosed with diabetes. These findings support the research by Taylor et al who showed that patients with diabetes had a tendency for increased caries activity.[19] When discussing these findings, it is important for health care providers to also consider that prior research documented that patients with diabetes had an increase in cariogenic bacteria and higher plaque levels, pointing to the significance of

sound oral health promotion efforts among these patients.[8,21]

When considering if diabetic patients could moderate their own oral health, the findings concerning increased levels of bacteria and plaque were used to determine the degree to which they would engage in constructive oral self–care. Unfortunately, Syrjala et al found that patients with diabetes had poorer oral health–related behavior compared to patients without diabetes,[25] and these findings were replicated in the current study as well. Patients with diabetes did not brush and floss as often as patients not diagnosed with diabetes. One could speculate that the increased amount of health–related activities that patients with diabetes need to engage in to control their diabetes might either preoccupy their attention or might prevent them from spending time on oral health–related activities that they might perceive as unrelated to diabetes or even as generally unimportant.[24] In any case, this study takes a new look at the relationship between diabetes and oral health by arguing that oral health–related behavior could be the moderating factor that might determine the strength of the diabetes–oral health relationship. Patients with diabetes who engaged in regular tooth brushing had better periodontal health and less caries compared to those with diabetes who did not brush as often. Patients with diabetes who did not cooperate with oral hygiene recommendations were less likely to have healthy probing depths of less than 4 mm compared to patients with diabetes who brushed regularly and had significantly higher percentages of decayed teeth compared to patients with diabetes who brushed regularly. It should be mentioned that patients with diabetes who brushed regularly versus those who did not brush regularly did not differ in socio–demographic background characteristics, such as age.

This new finding concerning the differences between patients with diabetes who brushed regularly versus those who did not brush regularly deserves attention, because it points to the importance of educating patients with diabetes about the importance of good oral hygiene efforts. In this context, it is also important to educate these patients about how to engage in productive oral hygiene efforts. The fact that 18% of patients with diabetes who brushed regularly had teeth with gingival recession compared to only 6% of patients with diabetes who did not brush regularly could potentially be an indicator that dental care providers need to make sure that patients with diabetes are aware of proper brushing techniques. Educating patients with diabetes about the importance of good oral health promotion and the prevention of oral disease is also crucial because prior research has shown that patients with diabetes may have a lower utilization rate of dental care services compared to patients not diagnosed with diabetes.[15]

In addition to educating patients about how diabetes can affect oral health, dental care providers also need to educate their patients with diabetes about the importance of good oral health for their glycemic control and the management of their diabetes. Research shows that severe periodontal disease can result in poor glycemic control and other complications.[15–17] The consensus is that there is a bidirectional relationship between diabetes and periodontal diseases.[16,18] If patients understand these relationships, they might be more motivated to engage in proper oral health promotion efforts.

Conclusion

These findings replicated prior research that showed diabetes and oral health are related, and that patients with diabetes might be less likely to engage in good oral health promotion efforts compared to patients not diagnosed with diabetes. However, the contribution of this study consists in the new finding that patients with diabetes who engage in regular brushing have significantly better oral health than patients with diabetes who do not engage in regular brushing – which should alert all clinicians to the crucial importance of oral health education efforts for patients with diabetes.

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Acknowledgments

References

1. Diabetes Fact Sheet. World Health Organization [Internet]. [cited 2010 July 23]. Available from: http://www.who.int/mediacentre/factsheets/fs312/en/index.html

2. Taylor GW, Borgnakke WS. Periodontal disease: associations with diabetes, glycemic control and complications. *Oral Dis*. 2008;14(3):191–203.

3. National Institute of Diabetes and Digestive and Kidney Diseases. National Diabetes Statistics, 2007 fact sheet. U.S. Department of Health and Human Services, National Institutes of Health. 2008.

4. Iacopino AM. Periodontitis and diabetes interrelationships: role of inflammation. *Ann Periodontol*. 2001;6(1):125–137.

5. Skamagas M, Breen TL, LeRoith D. Update on diabetes mellitus: prevention, treatment, and association with oral diseases. *Oral Dis*. 2008;14(2):105–114.

6. Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2003;26(Suppl 1):S5–20.

7. Löe H. Periodontal disease. The sixth complication of diabetes mellitus. *Diabetes Care*. 1993;16(1):329–334.

8. Hintao J, Teanpaisan R, Chongsuvivatwong V, Ratarasan C, Dahlen G. The microbiological profiles of saliva, supragingival and subgingival plaque and dental caries in adults with and without type 2 diabetes mellitus. *Oral Microbiol Immunol*. 2007;22(3):175–181.

9. Moore PA, Guggenheimer J, Orchard T. Burning mouth syndrome and peripheral neuropathy in patients with type 1 diabetes mellitus. *J Diabetes Complications*. 2007;21(6):397–402.

10. Moore PA, Weyant RJ, Etzel KR, et al. Type 1 diabetes mellitus and oral health: assessment of coronal and root caries. *Community Dent Oral Epidemiol*. 2001;29(3):183–194.

11. Oliver RC, Tervonen T. Diabetes––a risk factor for periodontitis in adults? *J Periodontol*. 1994;65(5 Suppl):530–538

12. Emrich LJ, Shlossman M, Genco RJ. Periodontal disease in non–insulin–dependent diabetes mellitus. *J Periodontol*. 1991;62(2):123–131.

13. Tsai C, Hayes C, Taylor GW. Glycemic control of type 2 diabetes and severe periodontal disease in the US adult population. *Community Dent Oral Epidemiol*. 2002;30(3):182–192.

14. Syrjälä AM, Kneckt MC, Knuuttila ML. Dental self–efficacy as a determinant to oral health behaviour, oral hygiene and HbA1c level among diabetic patients. *J Clin Periodontol*. 1999;26(9):616–621.

15. Thorstensson H, Falk H, Hugoson A, Kuylensti-erna J. Dental care habits and knowledge of oral health in insulin–dependent diabetics. *Scand J Dent Res*. 1989;97(3):207–215.

16. Taylor GW. Bidirectional interrelationships between diabetes and periodontal diseases: an epidemiologic perspective. *Ann Periodontol*. 2001;6(1):99–112.

17. Miller LS, Manwell MA, Newbold D, et al. The relationship between reduction in periodontal inflammation and diabetes control: a report of 9 cases. *J Periodontol*. 1992;63(10):843–848.

18. Mealey BL. Periodontal disease and diabetes. A two–way street. *J Am Dent Assoc*. 2006;137(Suppl):26S–31S.

19. Taylor GW, Manz MC, Borgnakke WS. Diabetes, periodontal diseases, dental caries, and tooth loss: a review of the literature. *Compend Contin Educ Dent*. 2004;25(3):179–184, 186–188.

20. Hintao J, Teanpaisan R, Chongsuvivatwong V, Dahlen G, Rattarasarn C. Root surface and coronal caries in adults with type 2 diabetes mellitus. *Community Dent Oral Epidemiol*. 2007;35(4):302–309.

21. Karjalainen KM, Knuuttila ML, von Dickhoff KJ. Association of the severity of periodontal disease with organ complications in type 1 diabetic patients. *J Periodontol*. 1994;65(11):1067–1072.

22. Matsuo S, Nakamoto M, Nishihara G, et al. Impaired taste acuity in patients with diabetes mellitus on maintenance hemodialysis. *Nephron Clin Pract*. 2003;94(2):c46–50.

23. Guggenheimer J, Moore PA, Rossie K, et al. Insulin–dependent diabetes mellitus and oral soft tissue pathologies: II. Prevalence and characteristics of Candida and Candidal lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2000;89(5):570–576.

24. Masood Mirza K, Khan AA, Ali MM, Chaudhry S. Oral health knowledge, attitude, and practices and sources of information for diabetic patients in Lahore, Pakistan. *Diabetes Care*. 2007;30(12):3046–3047.

25. Syrjälä AM, Ylöstalo P, Niskanen MC, Knuuttila ML. Relation of different measures of psychological characteristics to oral health habits, diabetes adherence and related clinical variables among diabetic patients. *Eur J Oral Sci*. 2004;112(2):109–114.

26. Kneckt MC, Syrjälä AM, Knuuttila ML. Attributions to dental and diabetes health outcomes. *J Clin Periodontol*. 2000;27(3):205–211.

27. Dental, Oral and Craniofacial Data Resource Center. NIDCR/CDC [Internet]. [cited 2010 July 25]. Available from: http://drc.hhs.gov/surveyq/preventive-care.htm

28. Cowie CC, Rust KF, Byrd–Holt DD, et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population: National Health And Nutrition Examination Survey 1999–2002. Diabetes Care. 2006;29(6):1263–1268.

29. Syrjälä AM, Kneckt MC, Knuuttila ML. Dental self–efficacy as a determinant to oral health behaviour, oral hygiene and HbA1c level among diabetic patients. *J Clin Periodontol*. 1999;26(9):616–621.